Telemetry strings, hardware reliability and transmission capabilities: update and outlook

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DURING RECENT INDUSTRY conferences and workshops, reliability figures for the use of telemetry drill strings have been disclosed for the latest wells drilled around the world. These statements of technical performance have had the objective of confirming that the installations of the telemetry network hardware within double shouldered drill strings do not affect the mechanical characteristics of the connections or tubulars.

This is directly related to the method of network installation within the drill string. A completely finished double-shouldered drill string manufactured from Grant Prideco is used as the base to install the network. The transmission between joints of pipe is performed by the use of inductive coils connected to a high-strength steel shielded cable that stretches from tool joint to tool joint. The inductive coil is fitted into a special centralized groove recess in the secondary shoulder of pin and box at the end of each joint, allowing coil pairs to match in front of each other as pipes are made up.

To maintain data integrity and signal-to-noise ratios, signal amplifiers (referred to as links) integrated into the drill string at appropriate spacing assure no data loss and allow acquisition of measurements along the string. The first generation of telemetry drill strings incorporate a temperature measurement sensor in every link, which is about 15 measurement points along the string in a 20,000-ft well.

Statistics collected about the performance of the network as of Q1 2008 are shown in the table below:

<table>
<thead>
<tr>
<th>Total wells drilled</th>
<th>40+</th>
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<tbody>
<tr>
<td>Total footage drilled</td>
<td>360,820 ft</td>
</tr>
<tr>
<td>Deepest well depth</td>
<td>20,610 ft</td>
</tr>
<tr>
<td>Highest recorded temperature in electronics</td>
<td>298°F</td>
</tr>
<tr>
<td>Highest inclination</td>
<td>98°</td>
</tr>
<tr>
<td>Fluid environments</td>
<td>OBM, WBM, foam, air</td>
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</tbody>
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The inductive coils in the pipe are embedded into the secondary shoulder and are transparent to the tripping in or out of the well.

There have been no hardware (tubular) mechanical reliability issues of any kind in any of the wells where telemetry drill pipe has been used to date. This is due to the fact that drilling tubulars used for network installations are double-shouldered (extreme torque) drill strings that already possess a strong reputation in the market place. The installation of the network in the drill string does not modify its mechanical or hydraulic properties.

During 2007, six commercial wells were drilled, with five of the six wells maintaining a network uptime average above 93%. In the additional well, a wired version of a reamer was used for the first time (as an Alfa test). This reamer experienced a telemetry component failure that prevented communication from the bottom of the string.

In short, the average uptime for commercial applications during 2007 was 83%. This means that for 83% of the time that data was required from the network, data came up. On projects where more than one well was drilled sequentially, an average of 97% uptime was observed.

Primary sources of network downtime were observed to be from surface tubular mishandling or surface cabling damage.

Statistics collected about the performance of the network as of Q1 2008 are shown in the table below:

| Fluid environments | OBM, WBM, foam, air |

The number of trips required to address a telemetry drill string network failure has again remained at zero during 2007.

Five main applications were enabled by use of telemetry strings during 2007 (more information can be obtained from the cited technical papers/presentations):

- Real-time control of bottomhole pressure by use of an annular pressure measurement, telemetry drill string and an annular dynamic pressure control system (IADC/SPE 112651).
- Real-time geosteering in a total fluid loss environment where downhole data was transmitted through the telemetry network to mitigate data loss (IADC World Drilling 2008).
• North Sea multilateral horizontal drilling in thin reservoir (SPE 110939).

• Enhanced decision-making by use of two-way communication to downhole MWD/LWD tools (SPE 112702).

• Wellbore stability management through formation images and drilling optimization by use of high-rate drilling dynamics measurements in real time (SPE 112636).

The above applications were enabled by the telemetry drill string network and were planned and executed by MWD/LWD and DD service companies that were prepared to transmit their real-time information through the network.

THE NEXT 5 YEARS

Now that bi-directional access to downhole tools data is unlimited, new and valuable applications are enabled. The greatest challenge for the industry is to uncover these applications and adapt the appropriate workflows that will enable industry experts and multi-disciplinary teams to apply their knowledge for the improvement of several projects at any one time. There are three specific milestones that the industry can easily reach in the near future with the combination of high-speed telemetry technology and downhole measurements.

Workflow-oriented applications

Drill string data is not more data; it is the same data received in a timely manner. This is the first milestone. The most important applications and resources that will be enabled by the use of telemetry drill strings, MWD and LWD is the real-time support centers that are designed to improve decision-making by use of the integration of surface and downhole data. To date, complete data sets of downhole data are not typically available while drilling. Current processes might not have been designed to use complete sets of data in real time.

Evaluation for drilling optimization

Formation characteristics will become part of the real-time drilling optimization process. The second milestone will be the ability to efficiently use formation evaluation data to increase drilling efficiency.

Before drill string telemetry, most formation evaluation requirements were set by the geosciences groups within oil companies. Drilling optimization-related acquisition and tooling on surface and downhole were planned and executed separately by drilling engineers or, in some cases, dedicated drilling optimization engineers.

Formation evaluation information acquired from downhole tools can be used for drilling optimization in more than a few ways without developing further methods than the ones that already exist today:

• Non-compressed formation images can be utilized for the identification of detailed drilling-induced fractures or borehole failure.
• Full re-logs of certain sections can be made during tripping out or in. This allows establishing a baseline for wellbore stability and analyzing the degradation with time.
• Real-time dip picking can be performed on uncompressed full images. Under certain circumstances, depositional and stress directions can also be determined.

The list goes on, and the logging-while-drilling and drilling optimization organizations will be able to determine the most efficient methods and applications in this domain.

Even today, an operator in the North America region has used logging-while-drilling formation density images to manage horizontal well stability. The operator managed to save a casing string by using the information within its wellbore stability group.

New applications

With almost unlimited access to downhole tool data in real time, a breadth of new and valuable applications are immediately enabled, including:

• Real-time use of high-density memory quality LWD formation data: Full formation data sets (including acoustic applications) available while drilling will enable drillers and geologists alike to make informed decisions while operations take place, bridging the decision-making gap. When there is more time to make a decision, less energy is spent in the logistics of the decision and more focusing on the facts that surround it.

• Surface-automated control of downhole rotary steerable tools (full “auto pilot”): Service providers have started to implement the infrastructure required to control downhole tools based on surface models. This will facilitate the real-time drilling centers concept by moving the complexity of controlling downhole tools from the rig floor to the control center.

• Real-time use of borehole imaging for wellbore stability management: Wellbore stability engineers have started to devise creative methods of utilizing real-time formation evaluation data to detect and prevent wellbore failure. With a combination of surface cuttings (morphology), azimuthal resistivity, density measurements and imaging, very little is left to guesswork, especially if a time-based analysis of wellbore failure can be performed to manage drilling parameters.
• Acquisition and use of basic drill string and annulus pressure measurements from "along string" locations: Proper use of drilling hydraulics is paramount to preventing the wellbore from over-pressure failure or break-out. Drill string telemetry technology also enables the ability to take measurements along the string to detect high-risk anomalies that might not be obvious when only measuring pressure at one point in the string.

• Real-time visibility of downhole tool performance parameters: After re-programming his tool from surface using the drill string telemetry network, an engineer said the downhole tools behave "as if they were on surface and directly connected to the surface system." In this case, this saved the operator a trip since tools cannot be re-programmed or extensively diagnosed from surface over mud pulse. The more reliable the downhole tools are, the more efficient the drilling can be.

• Real-time visibility of high-resolution drilling dynamics data to facilitate true drilling optimization: Basic measurements taken at different points along the drill string will yield visibility of the drilling process never before evaluated. This can help stabilize the drill string using objective methods based on actual measurements rather than models limited by boundary conditions. Although drilling optimization starts with string and well design in the planning phase, the ability to quickly adapt to unexpected changes during the drilling execution will quickly unveil the differences in performance and reduction in risk.

• Addition of basic measurement, command and control functionality to existing mechanical tools: With the telemetry drill string’s capability to move commands from surface to downhole and among different points in the drill string, very soon mechanical downhole tools will be able to know their state or be activated by a command rather than changes in fluid or compression, which can sometimes cause detrimental effects to the drilling process.

• Elimination of wireline cable from pipe-conveyed wireline logging operations: Pipe-conveyed logging is necessary to provide wireline-quality logs and sampling services in highly deviated wells. Having a wireline cable inside the moving drill pipe is currently the biggest liability in this operation. By adapting the logging tools directly to the telemetry drill pipe, this liability disappears, as well as the "blind" tripping that occurs from the time the tools are made on surface to the time they are connected to the wireline cable around shoe depth. For this, power to open and close calipers will be needed downhole.

Applications where telemetry drill strings can be used are many, and operators are adding new ones as these systems are implemented in different environments. The early development of the above applications will be, in our view, effortless.

References

The communication cable is connected to the coil inside the tool joints and stretched along the ID of the tubular without modifying its characteristics.

This photo shows how the inductive coils come together once the pipe is connected and achieve communication from pipe to pipe.